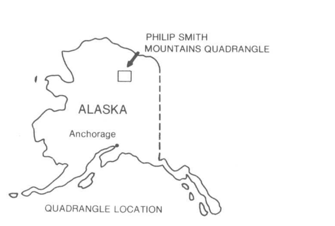
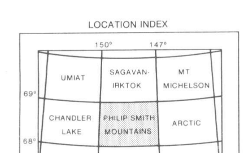
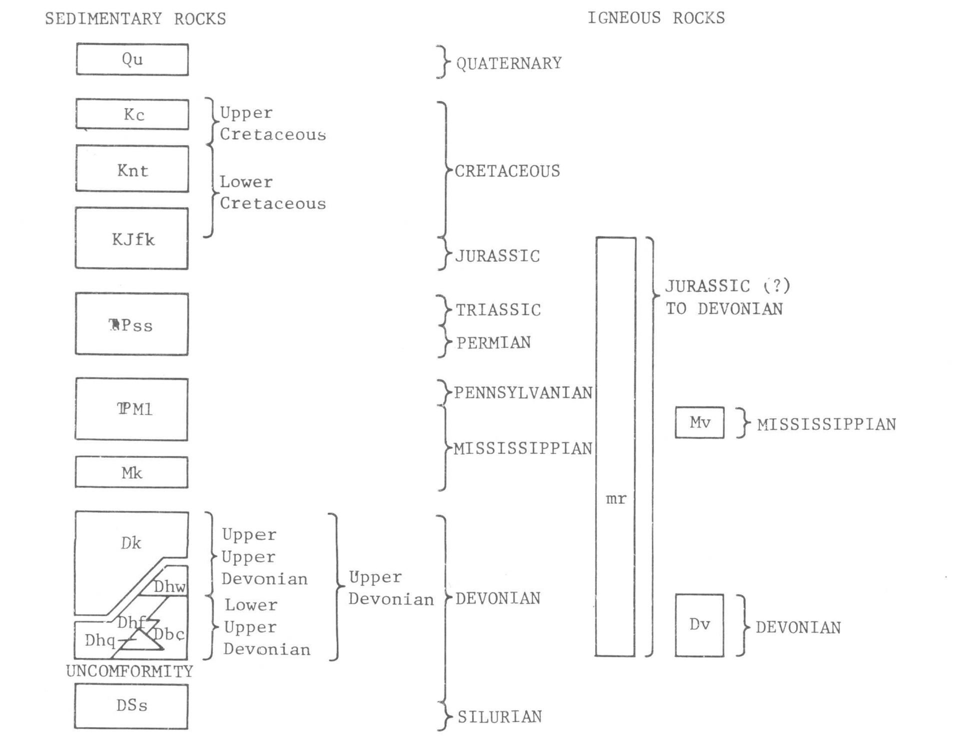
Base by U.S. Geological Survey, 1956

Geologic base modified from Brosgé and others, 1977





CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SEDIMENTARY ROCKS

Qu SURFICIAL DEPOSITS, UNDIVIDED (QUATERNARY)

Kc COLVILLE GROUP (UPPER CRETACEOUS)--Tuff; tuffaceous clastic rocks

Knt NANUSHUK GROUP (UPPER AND LOWER CRETACEOUS) AND TOROK FORMATION (LOWER CRETACEOUS)--Nonmarine and marine; sandstone, shale, siltstone and conglomerate

KJfk FORTRESS MOUNTAIN, OKPIKRUAK AND KONGAKUT FORMATIONS (LOWER CRETACEOUS) AND KINGAK SHALE (JURASSIC)-- Graywacke, dark-gray, partly manganiferous shale and siltstone, conglomerate

ℾPss SHUBLIK FORMATION (TRIASSIC) AND SADLEROCHIT GROUP (TRIASSIC AND PERMIAN)-- Phosphatic shale and limestone, partly calcareous siltstone and shale, sandstone, barite concretions

ℙMl LISBURNE GROUP (PENNSYLVANIAN AND MISSISSIPPIAN)--Limestone and dolomite

Mk KAYAK SHALE (MISSISSIPPIAN)--Black shale, limestone, sandstone

Dk KANAYUT CONGLOMERATE (UPPER DEVONIAN)--Nonmarine quartzite, ferruginous conglomerate, red shale. Basal marine sandstone

HUNT FORK SHALE (UPPER DEVONIAN)

Dhw Wacke member--Manganiferous shale and siltstone, ferruginous subgraywacke

Dhf Shale--Dark-gray shale and slate; quartzite, limestone. Thin mafic flow and sills

Dhq Quartzite member

Dbc CALCAREOUS SANDSTONE MEMBER OF HUNT FORK SHALE AND UNNAMED BROWN CALCAREOUS CLASTIC ROCKS (UPPER DEVONIAN)--Includes some reef limestone and red and green shale

DSs SKAJIT LIMESTONE (DEVONIAN AND SILURIAN)--Limestone, dolomite, marble. Few small mafic dikes

IGNEOUS ROCKS

Mv VOLCANIC ROCKS (MISSISSIPPIAN)--Diorite sill

Dv VOLCANIC ROCKS (DEVONIAN)--Pillow basalt flows

mr MAFIC ROCKS--Gabbro, diorite, and greenstone

GEOLOGIC CONTACT--Approximately located

FAULT--Dashed where approximately located

THRUST FAULT--Saw teeth on upper plate, Dotted where concealed

AEROMAGNETIC HIGH

K-●-●-●-K Axis--Most aeromagnetic highs on the map are equant and do not have axes

+ + + Axis lying over or close to a deep river valley--Probably caused by draped flying in vertical gradient of Earth's magnetic field

H-O-O-O-H AXIS OF AEROMAGNETIC LOW

TL AEROMAGNETIC LOW CAUSED BY TOPOGRAPHY--Caused by draped flying over high mountain peaks

O O O O TRACE OF A DEEP RIVER VALLEY UNACCOMPANIED BY AEROMAGNETIC HIGH--May indicate that the vertical gradient due to magnetic basement rock balances that of Earth's magnetic field

B INFERRED BOUNDARY BETWEEN MAGNETIC AND LESS MAGNETIC ROCKS--Dashed where buried by nonmagnetic cover; letters refer to description in text

(8) LENGTH OF STEEPEST ZONE OF MAGNETIC GRADIENT BOUNDING MAGNETIC HIGH--Estimate of the maximum distance between the magnetometer and the top of the magnetic source (measured in kilometers)

-50 MAGNETIC CONTOURS--Contour interval 10 gammas; index contour 50 gammas

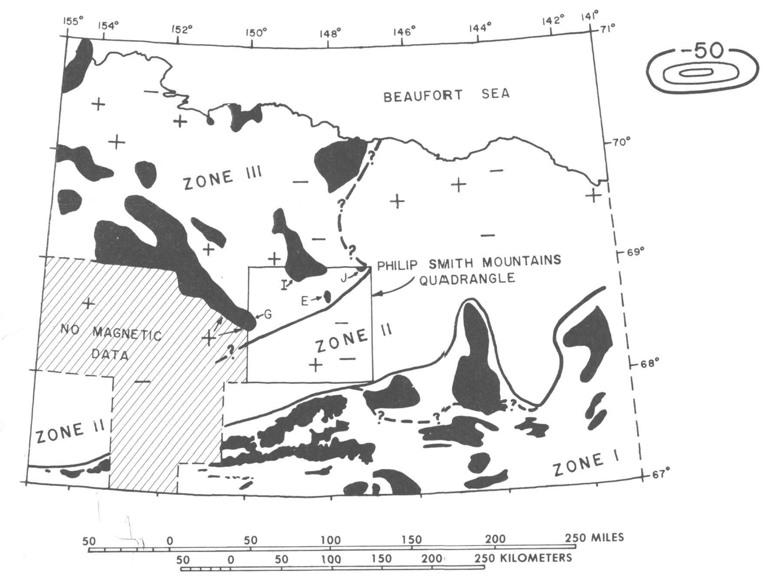


Figure 1.--Generalized aeromagnetic map showing regional aeromagnetic setting of the Philip Smith Mountains quadrangle. Black areas are aeromagnetic highs identified on the aeromagnetic compilation of Decker and Karl (1977). Owing to differences in datum and flight line elevation and spacing, the darkened areas have qualitative significance only. Symbols (+ and -) indicate gravity highs and lows from Barnes (1977). Letters E, G, I, and J denote magnetic highs shown on the larger scale map.

THIS MAP IS ONE OF A SERIES. ALL BEARING THE NUMBER MF-879. BACKGROUND INFORMATION RELATING TO THIS MAP IS PUBLISHED AS U.S. GEOLOGICAL SURVEY CIRCULAR 759, AVAILABLE FREE FROM U.S. GEOLOGICAL SURVEY, RESTON, VA. 22092

INTRODUCTION

The aeromagnetic map of Philip Smith Mountains quadrangle is remarkably featureless, owing to the absence of magnetic crystalline rocks within the thick sedimentary sequence of the northern Brooks Range. Hence, aeromagnetic data are of little use in delineating the configuration of near-surface rock units. Because of the very weak horizontal gradients caused by geologic features, the map is highly susceptible to errors caused by draped flying at a varying altitude within the vertical gradient of the Earth's magnetic field and by time variation of the Earth's magnetic field. The only major aeromagnetic highs occur in the northern part of the quadrangle and are caused by deep-seated sources of unknown rock type which have regional extent. Consequently, part of the following discussion deals with regional magnetic anomalies which lie principally outside Philip Smith Mountains quadrangle.

The following interpretation was made without benefit of field observation, after geologic mapping was completed (Brosgé and others, 1977).

AEROMAGNETIC DATA

The aeromagnetic map of the Philip Smith Mountains quadrangle was flown by Geometrics in 1976 and released by the U.S. Geological Survey in 1977. The data were collected along north-south traverses spaced 1.6 km apart. A Doppler system was used for navigation. The regional magnetic field, containing a trend of 1.35 gammas/km north and 1.90 gammas/km east, was removed using the 1975 International Geomagnetic Reference Field updated to 1976.

Topographic effects and time variations

The aircraft flew a nominal 300 ± 60 m above terrain (draped flying) unless terrain conditions demanded larger deviations in order to adhere to safety regulations. In practice, in the mountainous southern part of the quadrangle, the radar altimetry records show that the aircraft typically flew 300 m above ridgetops and 500 m above adjacent valleys. Over deep narrow valleys, however, the aircraft flew as much as 750 m above terrain, and cleared the highest ridgetops by as little as 50 m.

Over terrain composed of magnetic rocks, imperfect draped flying like that described above manifests itself as magnetic highs over ridgetops and lows over valleys. The effects are most easily seen in the radar altimetry and magnetometry strip charts. In the southern part of the Philip Smith Mountains quadrangle, variations in the height of the aircraft above ground of 200-500 m caused 3-5 gamma changes in the magnetic field, with the highs occurring over ridges and lows over valleys. Hence, the surface or near-surface rocks of the southern part of the quadrangle are magnetic, but very weakly so.

Another terrain effect, opposite in sign, occurs over valleys and ridges which are broad enough to allow the aircraft to maintain a constant elevation above ground. In the Philip Smith Mountains quadrangle, the vertical gradient of the Earth's dipole magnetic field, positive downward, is about 27 gammas/km. Descending into the Atigun River valley, for example, which is 600-900 m deep, the aircraft encountered a 16-24 gamma increase in the Earth's dipole field. An examination of the aeromagnetic map (T. 11-15 S., R. 11-12 E.) shows that a magnetic high with amplitude between 5 and 15 gammas follows the Atigun River valley. The difference between the predicted 16-24 gammas and the observed 5-15 gammas probably results from the weak but non-zero magnetization of surface or near-surface rocks described in the preceding paragraph.

Other river valleys besides the Atigun River valley, occurring in the southern two-thirds of the quadrangle, have weak magnetic highs associated with them. The highs associated with the valleys are indicated by elongate plus signs where they coincide with the valleys and by question marks where they diverge from the valleys. The question marks may indicate genuine, weak highs caused by magnetic rock, or they may indicate topographic highs displaced from valleys by navigation errors.

Other river valleys, marked by lines of circles, do not have highs associated with them. As many of these valleys are elongate transverse to the flight lines, the aircraft may not have descended as deeply into them as it descended into valleys parallel to the flight lines. In some cases, however, the absence of highs may be caused by vertical magnetic gradients opposite in sense to the vertical gradient of the Earth's dipole field. Such gradients, positive upward, are expected to occur within the magnetic lows that flank magnetic highs because the amplitude of the lows decreases with increasing distance from the source. Two possible examples occur in the Saviukviayak River valley, between highs E and I, and in the unnamed valley south of high F.

The correct approach to terrain and elevation effects would be to remove them analytically, using radar altimetry, and either digitized topographic maps or digital barometric altimetry, measured along flight lines. However, of these three data sets, only analog radar altimetry is available, so a terrain- and elevation-corrected map has not been made.

In many areas, low-amplitude anomalies and inflections (fine structure) in the magnetic field caused by susceptibility contrasts near the top of the basement, can be used to estimate the depth to magnetic basement. The aeromagnetic map of the Philip Smith Mountains quadrangle is inadequate for this purpose because the 10 gamma contour interval is too coarse, and short-wavelength anomalies were filtered out prior to contouring.

Attempts were made to find geologically significant fine structure in the raw aeromagnetic profile data and in an unfiltered aeromagnetic map with a 2 gamma contour interval. The 2 gamma contour map is marred by strings of 2-10 gamma highs and lows occurring on individual flight lines. The source of these anomalies could be time variations in the Earth's magnetic field for, according to contract, data collection was permitted during changes as rapid as 3 gammas per minute. The raw profiles contain many short-wavelength highs of 3-5 gammas which correlate with topography. No fine structure could be found on either the map or profiles which could be used to make reliable estimates of basement depth.

Aeromagnetic anomalies within the Philip Smith Mountains quadrangle

Eleven aeromagnetic anomalies, mostly highs, are labeled A through K. These are the only anomalies on the map which cannot be largely attributed to elevation effects. A number in parentheses gives the length in kilometers of the steepest zone of constant magnetic gradient bounding selected highs--an estimate of the maximum distance between the magnetometer and the top of the magnetic source (Vacquier and others, 1951). Lines drawn around the crests of closed highs show the approximate areal extent of the sources of the anomalies, estimated from charts A64 through A76 of Vacquier and others (1951). The sources may widen at depth beyond the dimensions shown. Solid lines delineate sources expected at or near the ground surface and dashed lines delineate sources buried by nonmagnetic cover. Anomalies caused by near-surface sources are listed first, followed by those caused by deeper sources.

The sources of highs A and B (in the southeastern quadrant of the quadrangle) are estimated to lie a maximum of 750 and 1000 m below the flight line, or 450 and 750 m below ground; mafic rock shown on the geologic map is probably the surface expression of the source.

Wiggles in the contour lines, labeled C in the west-central part of the quadrangle, may possibly indicate magnetic rock at the ground surface.

High D, which straddles the southern boundary of the quadrangle, is caused by a source buried by about 500 m of sedimentary rocks.

High E, and an adjoining poorly defined high labeled F in the northeastern quadrant of the quadrangle, are caused by sources buried by 1-2 km of sedimentary rock. As there is no associated gravity high (Barnes, 1977), the sources may be granitic plutons.

Highs G, I, and J, in the western and northern part of the quadrangle, are caused by sources buried by 4-10 km of sedimentary cover. They are associated with gravity highs of 5-15 mgal (Barnes, 1977). The sources for these highs may be deep-seated mafic intrusions.

The axis of the magnetic low separating highs G and I is labeled H. It indicates a zone of nonmagnetic rock in the basement.

The axis of an ill-defined magnetic high on the eastern side of the quadrangle is labeled K. It probably indicates a weakly magnetic zone in the basement or a deeply buried graben.

In the northern and western parts of the quadrangle, magnetic highs, often associated with gravity highs, indicate the presence of magnetic basement, shown on the interpretations at depths that range between 4 and 10 km. In the southern and eastern parts of the quadrangle, however, the magnetic field is lower, and there are no magnetic highs caused by deep-seated sources. This suggests a major boundary crossing the quadrangle from southwest to northeast, that separates magnetic basement to the north, containing significant quantities of mafic rocks, from a thick section of nonmagnetic sedimentary and metamorphic rocks to the south. Lack of resolution in the data makes this boundary difficult to locate. It certainly lies south of highs G and I, and probably lies south of highs E and J. Whether or not the sources for highs F and K belong to the northern terrain, is impossible to tell.

Regional aeromagnetic setting

Figure 1 is a small scale, generalized aeromagnetic map of a 4° by 14° area centered on the Philip Smith Mountains quadrangle. The data are from a compilation by Decker and Karl (1977) of several aeromagnetic surveys flown at different line spacings and elevations, so differences in magnetic texture must be interpreted with caution.

South of the Philip Smith Mountains quadrangle, the anomalies typically have high amplitude and short wavelength and trend approximately east-west (Zone I). North and west of the Philip Smith Mountains quadrangle, the anomalies have moderate amplitude, long wavelength, and typically trend northwest-southeast (Zone III). Highs E, G, I, and J, in the northern part of the Philip Smith Mountains quadrangle, and possibly highs F and K, shown on the larger scale map, belong to Zone III. An intermediate zone (Zone II), which contains the southern half of the quadrangle, is characterized by low magnetic relief and closed magnetic lows.

Two alternative boundaries are drawn between Zones I and II. The boundary composed of dashes and question marks is identical to the boundary between areas A and B of Brosgé and others (1968); it separates short-wavelength magnetic highs to the south from longer wavelength, low-amplitude highs to the north. The alternative boundary, shown by a solid line, lies north of the long-wavelength, low-amplitude highs. The boundary between Zones II and III is poorly determined, especially outside the Philip Smith Mountains quadrangle, where it is shown by dashes and question marks.

The short-wavelength anomalies of Zone I are caused by magnetic metamorphic rocks and granite exposed at or near the ground surface (Cady, 1978). The rocks of Zone II are principally sedimentary rocks which overlie the metamorphic rocks of Zone I. Presumably, magnetic metamorphic rocks and granite, if present beneath the exposed sedimentary rocks of Zone II, are so deeply buried that they have no aeromagnetic expression.

The rocks which cause the magnetic highs of Zone III are buried 1-10 km, according to rough depth estimates made by the method of Vacquier and others (1951). Many of the magnetic highs are associated with gravity highs from the map of Barnes (1977), shown with plus signs on figure 1. It is highly probable that portions of the basement in Zone III are dense and magnetic (probably mafic or ultramafic in composition). The boundary between Zones II and III truncates the southeast trend of the magnetic highs of Zone III. The boundary probably marks a transition between magnetic mafic or ultramafic basement rocks to the northwest and nonmagnetic or weakly magnetic metasedimentary and metavolcanic basement rocks to the southeast; this transition may extend to a depth of 10-15 km in the crust.

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AEROMAGNETIC MAP AND INTERPRETATION OF THE PHILIP SMITH MOUNTAINS QUADRANGLE, ALASKA

By
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